Department of Economics
School of Social Sciences

VALUING THE BENEFIT OF VARICELLA VACCINATION:
Comparison of Willingness to Pay and Quality-Adjusted Life-Years

By Mark Brisson and John Edmunds

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VALUING THE BENEFIT OF VARICELLA VACCINATION: COMPARISON OF WILLINGNESS TO PAY AND QUALITY-ADJUSTED LIFE-YEARS

M Brisson[1,2*],

1. Immunisation Division
PHLS Communicable Disease
Surveillance Centre
2. Department of Economics
City University

WJ Edmunds[1,2]

1. Immunisation Division
PHLS Communicable Disease
Surveillance Centre
2. Department of Economics
City University

*** Address for correspondance:** Merck Frosst Canada Ltd, 16711 Trans Canada Hwy, Kirkland, Quebec, Canada H9H 3L1, Tel: + 1 514 428-3746, Fax: + 1 514 428-2850

email:marc_brisson@merck.com

SUMMARY

Vaccination is different from most health interventions because it is preventative, it protects against infectious disease (leading to knock-on effects), the diseases it prevents are usually acute and self-limiting, and most vaccines are given to children from whom it is very difficult to elicit preferences. Because of its unique characteristics, vaccination may possess its own specific attributes. In this paper, we estimate the average Willingness to Pay (WTP) for varicella vaccination and the Quality-Adjusted Life-Years (QALY) lost due to chickenpox using Contingent Valuation (CV), Standard Gamble and Health Utility Index Mark II (HUI2). Furthermore, we identify what attributes of vaccination are important to vaccinees and what elicitation technique can capture these components. To do this, we administered computerised interviews to a sample of parents attending primary Health Centres. Using CV we demonstrate that individuals are willing to pay more for vaccination than treatment. Furthermore, we show that prevention of work loss is an important intervention attribute for parents. On the other hand, consistent with economic theory, the elicitation techniques used to estimate QALYs (Standard Gamble and HUI2) did not capture non-health benefits. Finally, results elicited using the CV were correlated with QALYs measured through the HUI2 questionnaire.

KEYWORDS: willingness to pay, standard gamble, quality-adjusted life-years, vaccination, attributes.

BACKGROUND

Most elicitation techniques have been developed for interventions that treat chronic diseases in adults. Vaccination has different characteristics, which may have an impact on which measures of benefit should be used when assessing the impact of immunisation programmes:

1) it is a preventative intervention,
2) it protects against infectious disease resulting in externalities,
3) the diseases it prevents can be short-lived and self-limiting,
4) most vaccines are given to young children from whom it is very difficult to elicit health/program preferences.

It has been argued that health is not the only source of well being derived from public health interventions (1-3). For vaccinees, the overall benefit of vaccination can be separated into 4 possible dimensions: 1) the direct effect on health, 2) altruism, and 3) insurance type benefit, and 4) work loss. To our knowledge no study has attempted to quantify these different attributes.

Direct effect on health. The principal benefit that can be derived from vaccination is that it prevents the vaccinee from acquiring disease and thus losing health related quality of life. Other direct effects on health could be the side-effects related to the vaccine itself.

Altruism. Preventing infection in a proportion of individuals in the population offers a degree of protection to others in the population (4). Because of this, the vaccinee (or vaccinee's parent) may derive benefit from the knowledge that by being vaccinated they will not infect other children (e.g. their siblings and friends). Such a benefit can be called altruism (*paternalistic* or *altruistic* Altruism).

Paternalistic or *altruistic* altruism occurs when individual A cares about individual B's consumption of health care and/or health status and this enters A's utility function (5,6).

Insurance type benefits. Immunisation offers protection against the uncertain future event of catching disease and its consequences. In these terms, being vaccinated can be viewed as taking insurance against disease. Because individuals are generally risk averse in relation to health, they may find an added benefit in the knowledge that they are protected against disease.

Work loss. Individuals may also find benefit in that vaccination (of their children) can also prevent them missing time off work or other inconveniences.

The feature that distinguishes between techniques of economic evaluation is the way in which the benefits of health care programmes are valued. Surprisingly few studies have directly compared WTP and QALY's (7-9). The results raise questions as to whether QALY's and WTP would lead to similar decisions concerning the allocation of health resources. Furthermore, no study has compared QALY's and WTP for immunisation, small changes in well-being or have examined if QALY's are truly incapable of measuring individuals non-health benefits.

The objectives of this paper are threefold: 1) to estimate Willingness to Pay for varicella vaccination using Contingent Valuation (CV) and the Quality Adjusted Life Years (QALY) lost due to chickenpox from Standard Gamble (SG) and the Health Utilities Index mark 2 (HUI2), 2) to compare results from the various elicitations techniques, and 3) identify what attributes of vaccination these elicitation techniques can capture.

METHODS

Ethical approval, Sampling and Survey design

Ethical approval was granted by the Public Health Laboratory Service (PHLS) ethics committee and the *Barnet, Enfield* and *Haringey* Local Research Ethic Committee.

The study population consists of parents. Parents were used as proxies for their children since at the time of chickenpox vaccination (or disease) the child is too young to reveal his/her preferences (10-12). Furthermore, it is the parent who decides whether or not their child is vaccinated. We recruited all parents regardless of whether or not their children had prior history of varicella. For ethical reasons, the only exclusion criterion was age greater than 18 years.

Parents and caregivers were recruited from primary Health Centres in Enfield, London at the time of routine infant and child check-ups. Parents were approached in the waiting room where they were given an information leaflet and asked to participate in the study. Those consenting to participate were given a computer active interview.

Questionnaires

The computerised questionnaire was programmed in Visual Basic within Microsoft Access. Before the start of the main study, a pilot study was conducted to finalize the questionnaire. The computer active pilot questionnaire was administered to 89 parents. From the pilot we concluded that respondents had little difficulty answering the questionnaires and that the bidding scales used produced adequate distributions. The final computer active questionnaire is structured into 3 parts and is available from the authors on request.

Part 1: Socio-demographic questionnaire. In *part 1*, respondents were asked standard socio-demographic questions including age, sex, level of education and annual income. Respondents were asked whether their children are fully vaccinated for their age in order to have an idea of the parent's general attitude towards vaccination; if they need to take time off work when their child is sick; and whether any of their children have had chickenpox.

Part 2: Contingent Valuation or Standard Gamble questionnaire. In *part 2*, respondents were given one of two different types of questionnaire: 1) CV and 2) SG. Each parent or caregiver responded to only one type of question.

***Contingent Valuation*:** The respondents were given a description of the health profile of a child with chickenpox (Box 1). Initially respondents were asked to assume that their child has chickenpox and that a drug exists which can cure their child immediately. We then elicited the maximum the respondent is willing to pay for the drug using a bidding algorithm (Table 1). In the second section of the CV questionnaire, respondents were asked the maximum they were willing to pay to vaccinate their child against chickenpox (i.e. to prevent their child having chickenpox sometime in the future). We used the ex-post user-based perspective (respondents were asked to assume they are at the point of intervention) for comparability with the SG, which has a similar perspective. However, as immunisation offers protection against the uncertain future event of catching disease the second section (vaccination question) has characteristics of insurance-based questions (i.e. respondents are at the point of intervention but not in the disease state).

Respondents were given randomly one of 4 different contingent valuation questionnaires. The questionnaires differed in their description of the effectiveness and consequences of the intervention. Table 2 describes the different components included in the 4 questionnaires. By comparing the willingness to pay between and within the different questionnaires it was possible to estimate the value parents place on vaccination and its different attributes.

Overall benefit of chickenpox vaccination in vaccinees: This is estimated by assessing the average willingness to pay for chickenpox vaccination when effectiveness is 85% (as estimated from clinical studies (13)).

Attributes of vaccine programmes: The *direct health effect* of preventing a case of chickenpox was measured by estimating the average willingness to pay for chickenpox treatment when efficacy is 100%. It should be pointed out that, following the request from the ethics committees, parents were asked to assume that vaccination and treatment had no side effects. The value parents' put on preventing their child infecting others (*altruism*) was measured by comparing the WTP from questionnaires stressing this effect to those in which the effect was not mentioned. The benefit of security (*insurance type benefit*) was measured by comparing the difference in parent's willingness to pay for treatment and vaccination. Finally, the value of *parental work loss* was measured by estimating whether parents who must take time off work when their child is ill are willing to pay more to prevent chickenpox than those who do not, controlling for factors such as household income.

Standard Gamble: A separate group of respondents were asked to imagine that their child is in an imaginary health state for 15 years (see Box 2 for description).

The duration of disease was chosen so that parents would trade risks of death for intervention and it is the time-span of childhood. Apart from the duration of disease, the health profile is identical to the description of chickenpox. Interviews using the CV and SG questionnaires were given on different days.

Respondents were given randomly one of 2 different SG questionnaires. The only attribute varied in the SG questionnaire was *altruism*. In half of the questionnaires a*ltruism* was included by stressing that treatment will prevent the child from giving the disease to other children. In the remainder there were no mention of knock-on effects. Probabilities were presented numerically and visually to make clear the risks that were being traded-off. Visual aids were similar to those presented by Appel *et al*. (14), and are available on request.

Experimental design

The experimental design used was a combination of conjoint analysis and CV or SG. That is, we present individuals with various scenarios that include different attributes (conjoint analysis) and from which we obtain preferences using CV or SG. Respondent's maximum WTP or maximum acceptable risk to return to perfect health (SG) was assessed using bidding algorithms (see Table 1). Starting point bias has been identified in such algorithms (8,15,16). To test and control for starting point bias, we used three randomised starting bids for the CV and SG questions (Table 1).

Part 3: Health Utilities Index mark 2 (HUI2) questionnaire. In *part 3* we ask the respondents to rate the health state that has been described to them (chickenpox (CV) or the imaginary disease (SG)) using an existing generic health status index (Health Utilities Index mark 2 (HUI2)). This enables us to estimate the QALY loss

due to chickenpox as well as validate the WTP and SG responses. Because it was developed for childhood diseases using parents as proxies and utilities were derived using SG (17), HUI2 is an ideal tool to validate responses from Part 2 (CV and SG questionnaires).

Data Analysis

CV and SG model. The respondents' answers to the questions did not directly reveal their maximum WTP (CV) or their maximum acceptable risk to return to perfect health (SG). The responses only provided bounds. For example, a respondent who replied *yes* to £100 but *no* to £150 is assumed to have a WTP value between £100 and £150. Furthermore, the data are both right and left censured. That is, the lowest bid for WTP was £0 (0.1% for SG) and highest £200 (20% for SG). Interval regression was used because it can estimate models for point, interval and censured data. Using this method we estimated the average WTP for chickenpox treatment and vaccination (CV) and average acceptable risk (SG). Furthermore, we tested which intervention and respondent attributes affected the results as well as whether there was starting point bias. The variables and attributes included in the regression are listed and described in Table 3.

Analyses were carried out in Stata v.7.0. (StataCorp, 2002). The data generated from the study sample were re-weighted to be representative of the population of parents with children of vaccination age in England. Weights for the CV and SG analyses are presented in Table 4. The final multivariable models used to estimate the average WTP and SG and to identify significant variables were selected using the following method. Firstly, univariable analyses identified variables that were significant ($p<0.2$ level) for inclusion in the multivariable models. Secondly, the identified variables were added to the model and retained if they remained

significant ($p<0.1$ level). Finally, the variables that were excluded at the univariable stage were included one by one to assess whether they became significant.

Analysis of refusals. In the CV questionnaire respondents have the option to not accept the intervention even at zero cost (equivalent to refusing chickenpox treatment and vaccination for their children). We used logistic regression to examine determinants of the decision to refuse chickenpox intervention. In the analysis, the dependant variable was 0 if the respondent refused intervention and 1 otherwise with independent variables presented in Table 3.

QALY-weight estimation. As described above, the average maximum risk of instant painless death parents were willing to accept for their children was estimated using interval regression. From this a QALY-weight can be estimated using the standard technique and compared to those estimated from the HUI2 system using the scoring formula published by Torrance et al. (17). The overall average QALY-weight and determinants was assessed using linear regression. The variables included in the regression are listed in Table 3. Both responders to the CV and the SG filled in the HUI2. The description of disease was identical in the two questionnaires apart from duration. That is, in the CV questionnaire the disease is assumed to be for a week and in the SG it is assumed to last for 15 years. We term HUI2-CV and HUI2-SG the Health State described to CV and SG respondents respectively. By comparing HUI2-CV and HUI2-SG we test whether duration of disease has an impact on QALY weight as measured by HUI2.

RESULTS

CHARACTERISTICS OF RESPONDENTS

Table 4 presents the characteristics of the 202 and 63 parents who answered the CV and SG questionnaire respectively, and how they compare to women with children under 5 years in the general population of England. Because, there were fewer attributes tested in the SG questionnaire, the sample size was lower than the CV questionnaire. The characteristics of parents who responded to the questionnaires were similar (Table 4). Because the setting was in baby clinics, the parents interviewed had very young children. This was intended, as we sought to recruit parents of children that were close to the age of vaccination and who were susceptible to chickenpox. Compared to national statistics (www.statistics.gov.uk), the parents of the sample were older, more educated and had a higher household income (see Table 4 for details).

WILLINGNESS TO PAY – CV QUESTIONNAIRE

Distribution of WTP responses

All respondents to the CV questionnaire (202 parents) were asked their WTP for both chickenpox vaccination and treatment. Twenty-nine and 31 parents said they would not have their child treated and vaccinated, respectively, even if it was free. Of the parents who were willing to have their children both treated and vaccinated, 49 were WTP more for vaccination, 5 were WTP more for treatment and 111 provided identical WTP. Using McNemar's test for paired data, the WTP for vaccination was found to be significantly higher than for treatment (χ^2=34, p-value<0.0001). This suggests that parents find an added benefit in prevention – i.e. that *insurance type benefits* exit.

WTP analysis

The WTP analysis is divided into 3 sections. First, we analyse the complete dataset assessing the average overall preference of parents taking into account those who

would refuse the intervention even if it were free. In the second section, we examine the variables, which determine whether or not parents refuse chickenpox treatment or vaccination. Thirdly, we analyse the WTP of parents who desire chickenpox treatment and vaccination for their children.

WTP analysis with refusals. Results from the interval regression model are presented in Table 5. Significant variables ($p < 0.05$) for both the WTP for treatment and vaccination were *Vaccinated*, *Work Loss*, *Income*, *HUI2* and *Start Bid*. Parents of children who are fully vaccinated for their age (*Vaccinated*=0) are willing to pay £107 and £134 more for chickenpox treatment and vaccination, respectively than those who are not. Furthermore, controlling for other variables, parents who must take time of work when their children are sick (*Work loss*=0) are WTP £32 (£38) more for treatment (vaccination). Results also suggest there is starting point bias. WTP for treatment and vaccination is significantly higher for respondents who were given the £75 starting bid (*start bid*: $p<0.05$ Table 5). Finally, as expected by theory, WTP increases with the household income (*income*: $p<0.05$) and with perceived severity of chickenpox (*HUI2*: $p<0.05$). It should be noted that *altruism* and *efficacy* were not found to be significant factors in parents WTP for chickenpox treatment and vaccination.

Analysis of refusals. Table 6 reports the results from the logistic regression of acceptance/rejection of chickenpox treatment and vaccination. Significant variables are *Vaccinated*, *Work* and *HUI2*. Parents of children who are fully vaccinated for their age (*Vaccinated*=0) are estimated to be 6 (1/0.16) times more likely to accept treatment or vaccination. Furthermore, parents who work (*Work*=1) were 3 times more likely to accept intervention against chickenpox.

Finally, those who accepted treatment or vaccination thought chickenpox to be more severe then those who did not.

WTP analysis without refusals. Table 7 reports the results from the interval regression model of WTP of parents who desired chickenpox treatment or vaccination for their children. Significant variables for both the WTP for treatment and vaccination were *Work Loss* and *Income*. Controlling for other variables, parents who must take time off from work when their children are sick (*Work loss*=0) were willing to pay £26 (£24) more for treatment (vaccination). Interestingly, the perceived severity of chickenpox was not significant in the amount parents were WTP. Thus, perceived severity seems to be a significant factor in whether or not parents would want their child to be treated (or vaccinated – Table 6) against chickenpox but not the amount they are WTP (Table 7). Once parents have decided they were willing to treat (or vaccinate) their children, the most important factor in their maximum WTP for intervention was their income (i.e. their capacity to pay). *Altruism* and *efficacy* were not found to be significant factors in parents WTP.

Mean Willingness to pay. Table 8 presents the estimated average WTP for chickenpox treatment and vaccination for the study sample and the population of England. The average WTP for the sample is higher than for England because it has a higher income, higher level of education and older population. From Tables 5-7 it is possible to estimate the monetary value of the various attributes of varicella vaccination. *Altruism* was not significant in the WTP models. In our sample, the *insurance type benefit* is estimated to be £18.84 (£140.45 – £121.61, Table 8). Furthermore, the average value of parental *work loss* in the sample was £10.72 per

individual (£26.41*Proportion of parents who do not take time of work (41%), Table 4 and 5).

QUALITY-ADJUSTED LIFE-YEARS – SG QUESTIONNAIRE

Table 9 reports results from the interval regression model of parents' maximum acceptable risk. Fathers were willing to take, on average, a 7% greater risk of death for their child to return to normal health than mothers. Furthermore, respondents without a degree were, on average, willing to take a 6% higher risk than those with a degree. Parents who were told their child could transmit the imaginary disease to other children were willing to accept a 5% greater risk of death than those who did not.

The average risk of death accepted by respondents was 9% (95%CI 7%-11% - Table 8). This corresponds to a QALY-weight of 56% (95% CI: 45%-66%). The average risk of death that would be acceptable to parents is predicted to be higher for the population of England (14%; resulting QALY-weight 31%) than for the study sample, because the study sample has a high proportion of parents with a degree.

QUALITY-ADJUSTED LIFE-YEARS - HUI2 QUESTIONNAIRE

Table 10 reports results from the regression model of QALY-weights elicited from respondents of the CV and SG questionnaires, respectively, using the HUI2 system. For respondents of the CV questionnaire, the single significant variable was *Chickenpox*. Respondents whose children had not had chickenpox (*Chickenpox=1*) believed chickenpox to be more severe (lower QALY-weights). For respondents of the SG questionnaire, *Altruism* was the lone significant variable. Parents who were given the *altruistic* questionnaire had a significantly lower QALY-weight. The standard gamble and HUI2-SG produced identical QALY-weights (56%). However,

this was significantly different from the 76% (95% CI: 74%-78%) calculated from HUI2-CV.

DISCUSSION

In this paper we used various elicitation techniques (CV, SG and HUI2) to estimate parent's WTP for varicella vaccination and the QALY lost due to chickenpox and to identify the different attributes of vaccination.

Conjoint valuation. The average WTP for parents who desired varicella vaccination, corrected to represent the population of England, was £120.21. Three attributes of vaccination were measured: 1) *direct health benefit*, 2) *insurance type benefit*, and 3) parental *work loss* (Table 8). The *direct health benefit, insurance type benefit* and *work loss* represented 79%, 13% and 8% of the average WTP for vaccination respectively. To our knowledge, this is the first study to show, empirically, that individuals prefer vaccination (prevention) to treatment and that quantifies parent's WTP to prevent work loss.

WTP for vaccination was significantly greater than for treatment indicating that individuals find an added benefit in the security that their child will not develop chickenpox (*insurance type benefit*). In theory, this is expected since individuals are risk averse and therefore there exists a potential for improving welfare by reducing or eliminating uncertainty. Previous studies have shown that the expected WTP assuming risk neutrality (WTP to treat, ex post, multiplied by the risk of the event) is lower than the elicited WTP using the ex ante insurance-based question (18,19). Here, there is a difference in that both the treatment and vaccination questions are ex post user-based. Furthermore, the risk of acquiring chickenpox is close to 100%. Hence, contrary to previous studies (18,19), the *insurance type*

benefit that is quantified cannot be biased because of differences in the valuation perspective (ex ante vs. ex post) or individuals misunderstanding the risks of disease. It should be pointed out that, in our calculation of the *insurance type benefit,* we do not take into account discounting, which would render the added benefit of vaccination greater. Since chickenpox occurs on average at 6 years of age in the UK, the present value of treatment (assuming discounting) will be lower than the elicited WTP, which supposes the child is currently unwell.

Work loss was a significant factor in parents WTP for vaccination after controlling for other factors such as income. This raises questions of whether prevention of *work loss* should be included in the denominator of the cost-benefit ratio (is a benefit), the numerator (is a societal productivity gain) or both. Care must be taken when conducting Cost-benefit analysis not to double count these cost/benefits.

Although other studies have found evidence of *altruism* (20-22), it was not identified as a significant variable in this study. Previous studies measured *altruism* by comparing private versus public WTP for an intervention (7). That is, they measured respondent's preference for subsidising fellow citizens' health care (caring externality (23)). Here, we attempted to measure a different type of *altruism*, which is specific to prevention of infectious diseases. We estimated whether individuals derive benefit from not infecting others (i.e. family and friends) because they are immunised. This benefit may not have been detected in our analysis because of the lack of power of the study to measure very small differences in WTP, because chickenpox is too mild to produce such altruistic benefits, or because this particular type of *altruism* does not exist. Further research is needed on this issue. As expected by economic theory, WTP increased

with perceived severity of disease (*HUI2*) and *income*. However, contrary to other studies, effectiveness of the vaccine was not found to be a significant factor in parent's decision to vaccinate (24,25). This is most likely because, parents were told that although the vaccine had 85% effectiveness; cases among vaccinated children were very mild.

Validations of CV studies are very difficult due to the hypothetical nature of the questions (8,26). In this study, responses to the CV questionnaire were consistent with expected theory. WTP for vaccination (and treatment) increases with income until a point at which it starts to decline (*construct validity* - Tables 5 and 7). Secondly, the perceived severity of disease as measured by the HUI2 system significantly affected parents overall WTP for chickenpox vaccination and treatment, which demonstrates *convergent validity* and that WTP increases with perceived benefits (Table 5).

Standard Gamble. The average QALY-weight estimated from the SG analysis was 56% for the study sample and 31% when adjusted for the overall population of England. *Work loss* was not found to be a significant factor of the SG. This result is consistent with the general belief that QALYs cannot capture non-health benefits (3,27).

The effect of *Altruism*, *Gender* and *Degree* were significant (Table 9). The QALY-weight elicited from parents who were told that intervention would prevent their child giving the disease to other children was 0.25 lower than those who did not have this attribute. This may be an *altruistic* or a *paternalistic* externality or a *direct health* valuation. We show that parents who were given the *altruistic* scenario believe that the disease was more severe (the QALY-weight derived from

the HUI2-SG questionnaire was significantly higher (Table 10)). Hence, it is more likely that the SG did not capture externalities but actual valuations of health.

Fathers were willing to take greater risks to return their children to normal health (QALY-weights were 0.35 lower than for mothers). This is consistent with other studies, which show that for an identical health state QALY-weights elicited from women are higher (28,29). Finally, having a *degree* was found to be significant, which suggests that understanding of risk may be an important factor in standard gamble elicitation despite the fact that visual aids were used. This corroborates a previous study (18). That gender and level of education influence SG responses may raise equity concerns.

Health Utility Index mark 2. The QALY-weight distributions estimated from the HUI2 system were much lower in those given the HUI2-CV compared with HUI2-SG questionnaires (0.76 vs. 0.56 – Table 8). The only differences between the CV and SG disease descriptions were that duration of disease was extended to 15 years in the SG questionnaire (in order for parents to trade-off probabilities that they could understand), and parents who were given the CV questionnaire were told they were valuing chickenpox. Difference between the QALY-weight elicited from HUI2-CV, HUI2-SG and the SG questionnaires illustrate the measurement problems of estimating QALY-weights for acute diseases using SG and similar elicitation methods. The main problem is that, for acute and mild diseases, such as chickenpox, the rational risk that individuals should be willing to trade-off is too small for most to comprehend. To get around this we can increase the duration of the disease state, assuming constant proportional trade-off, while keeping the same health state description. Here, this technique does not seem to work. This can be due to two reasons. Firstly, the proportional trade-off assumption may not

hold. Many studies in the literature show that the QALY-weight is dependent on the time individuals are in the disease state (30-35). The second problem is that by increasing duration of disease and refraining from mentioning chickenpox, individuals are actually rating an imaginary disease that they have difficulty understanding. That is, parents are rating a different disease. This seems to be the case as HUI2-CV and HUI2-SG give different QALY-weights.

As mentioned earlier, the HUI2 system and other multi-attribute health status classification systems have two major advantages over SG when estimating the morbidity of infectious diseases: 1) they are simple to understand and answer and, 2) they can capture small changes in heath status (36,37). In this study individuals who responded to the HUI2-CV had little difficulty responding to the questionnaire. This was aided by the fact that chickenpox was known to most parents. Despite this, QALY-weights were significantly higher for parents of children with positive history of the disease (Table 10), which raises the question about who should be answering elicitation questionnaires. Should it be those who are at risk or affected by the disease or the general public? De Wit *et al*. (36) consider this question in detail.

Limitations of the analysis. The analysis presented here has four main limitations: 1) it uses parents as proxies, 2) a bidding algorithm was used, 3) the impact of vaccine side effects and risk of disease on WTP and SG were not directly elicited, 4) a vaccination scenario was not included in the SG questionnaire.

Parents are used as proxies. Varicella vaccination is mainly carried out on very young children, from whom it is impossible to elicit preferences. We used parents as proxies as they are the ones who are responsible for the health of their children

and decide whether they receive vaccination. A number of problems have been observed when using parents as proxies (38). Firstly, for multi-attribute health systems, although results are correlated between parents and children, parents report a greater effect of illness on the quality of life of their child (39-42). This has also been observed to be true when comparing elicitation techniques between patients and other proxies (36). On the other hand, parents may be more risk averse for their children than for themselves. Hence, SG using parents as proxies is likely to underestimate the QALYs lost. Secondly, if parents are used as proxies, QALY and WTP measures may integrate to some degree the indirect effects on the parents (e.g. psychological, monetary). A good example of this is that parents who must take time off work are willing to pay more for vaccination.

Impact of vaccine side effects and risk of disease on coverage and WTP. Decision to immunise or not is influenced by individuals' fear of side effects and the severity of disease (43). However, as mentioned above, we could not measure the extent to which these factors have an effect on vaccine coverage and WTP for vaccination because of ethical considerations. Although varicella vaccine side-effects are typically mild (44-46), results from the CV may overestimate parents WTP for vaccination.

Bidding game. To increase precision and the power of our study to detect attributes, we used a bidding game (iterative-close ended questioning approach) to elicit maximum WTP, which may induce starting-point bias (16,47-51). Starting point-bias was identified here (Table 5), though it was controlled for when estimating the values of the different attributes of vaccination. Furthermore, starting-point bias was not a significant factor when assessing the maximum WTP for vaccination or treatment when excluding responses of those who refused

intervention.

A vaccination scenario was not included in the SG questionnaire. We did not include a vaccination scenario in the SG questionnaire because of ethical reasons. When ethical approval was originally sought (in 2001), vaccine coverage had dropped in the UK due to the alleged concern of the safety of the MMR vaccine. Including a scenario in which vaccination could cause death in a proportion of children could have provoked more worry in parents and have had deleterious consequences on vaccine coverage.

Strengths of the analysis. For the CV questionnaire we follow Carson et al.'s (52) conditions for a valid CV scenario and National Oceanic and Atmospheric Administration (NOAA) recommendations (53). As recommended by the NOAA panel we used face-to-face interviews, reminded respondents that the money is from their own disposable income (out-of-pocket), used a binary CV format and demonstrated sensitivity of scope.

The analysis presented here expands the health economic literature in two major areas. We present for the first time empirical evidence that individuals prefer prevention to treatment (insurance type benefit exist) and that in their decision to accept an intervention for their children, parents value the benefit of preventing time off work (work loss benefit). This study is also the first to assess, using empirical results, the advantages/disadvantages of different elicitation techniques in the context of valuing the benefit of vaccination.

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CONFLICTS OF INTEREST

Marc Brisson currently works for Merck Frosst Canada Ltd. The research, analysis and first draft of the manuscript were done prior to Marc Brisson's employment at Merck-Frosst.

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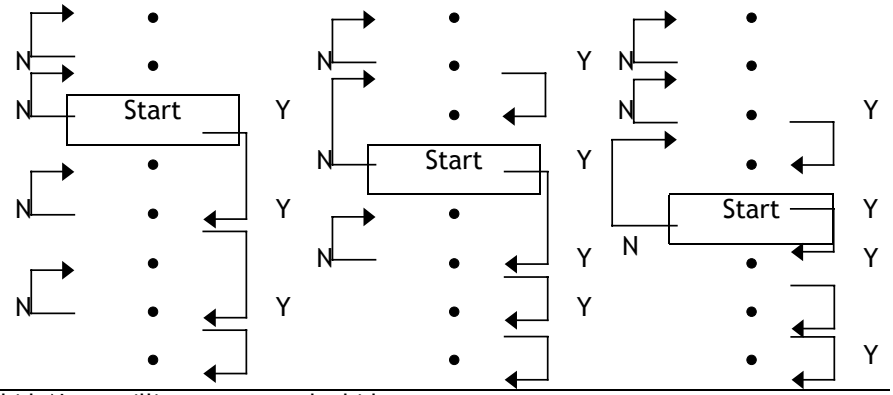
Table 1. Bidding Scales and Bidding algorithms for WTP and SG questions

WTP Bid Scale	SG Bid Scale	Bid Algorithm 1	Bid Algorithm 2	Bid Algorithm 3
£0	0.1%			
£10	0.5%			
£25	1%			
£50	2%			
£75	5%			
£100	10%			
£150	15%			
£200	20%			



Y, willing to accept the bid, N not willing to accept the bid.

For SG, if a person is indifferent we stop the bidding.

Table 2. Attributes varied in the CV questionnaires

	Efficacy		Altruism[C]
	100%[A]	85%[B]	
WTP Questionnaire 1		✕	✕
WTP Questionnaire 2		✕	
WTP Questionnaire 3	✕		✕
WTP Questionnaire 4	✕		

A. 100% efficacy for **Treatment** was described as follows: *With the drug your child will return immediately to normal health*. 100% efficacy for **Vaccination** was described as follows: *With the vaccine your child will never get chickenpox.*

B. 85% efficacy for **Treatment** was described as follows: *With the drug your child has an 85% chance of being immediately cured, and a 15% chance of getting mild chickenpox*. 85% efficacy for **Vaccination** was described as follows: *With the vaccine your child has an 85% chance of never getting chickenpox, and a 15% chance of getting mild chickenpox*.

C. Altruism was described as follows: *With the drug (or vaccine) you prevent your child from giving chickenpox to other children.*

✕ indicates that the attribute is included in the description of the intervention.

Table 3. Independent variable specification

Variable	Description
Gender	0=female, 1=male
Age	age in years
Degree	0=degree, 1=no degree
Work	0=does not work, 1=works
Vaccinated	0=children are fully vaccinated for their age, 1=children are not fully vaccinated, 9=don't know or did not answer
Work loss	0=Need to take time off work when child is sick, 1=Does not need to take time off work
Children	1=1 child, 2=2 children, 3=3 children, 4=4 or more children, 9=did not answer
Chickenpox[A]	0=at least one child has had chickenpox, 1=no child has had chickenpox, 9=don't know or did not answer
People	1=1 person in the household, 2=2 people in the household, 3=3people in the household, 4=4 people in the household, 5=5 people in the household, 9=did not answer
Income	0=annual household income before tax is less than £15,000, 1=£15,000-24,999, 2=£25,000-39,999, 3=£40,000-59,999, 4=more than £60,000, 9= did not answer
Altruism[B]	0=altruism, 1=no altruism
Efficacy[A,B]	0=100% efficacy, 1=85% efficacy
HUI2[B]	QALY weight of chickenpox as measured by the HUI2 system
Start Bid	0= start bid is £25 (CV) or 1% (SG), 1= start bid is £50 (CV) or 2% (SG), 2= start bid is £75 (CV) or 5% (SG)

A. Not included in the SG analysis.
B. Not included in the HUI2 analysis.

Table 4. Characteristics of respondents

	CV		SG		Population	CV Under-representation	SG Under-representation
	N	(%)	N	(%)	%		
Gender							
Male	18	(9%)	7	(11%)			
Female	183	(91%)	56	(89%)			
***Age* (years)**							
< 20	5	(2%)	2	(3%)	(8%)[A]	0.31	0.40
20-29	65	(32%)	25	(40%)	(47%)	0.68	0.84
30-39	124	(61%)	31	(49%)	(43%)	1.43	1.14
40+	8	(4%)	5	(8%)	(2%)	1.98	3.97
Degree							
Yes	96	(48%)	31	(49%)	(28%)[B]	1.70	1.76
No	106	(52%)	32	(51%)	(72%)	0.73	0.71
Work							
No	84	(42%)	22	(35%)	(46%) [C]	0.90	0.76
Yes	118	(58%)	41	(65%)	(54%)	1.07	1.21
Number of *children*							
1	123	(61%)	43	(68%)			
2	63	(31%)	15	(24%)			
3	14	(7%)	4	(6%)			
4+	2	(1%)	1	(2%)			
Age of children (years)							
0	149	(53%)	43	(48%)			
1-4	100	(36%)	33	(37%)			
5+	32	(11%)	13	(15%)			
Children fully *vaccinated*							
yes	186	(92%)	56	(89%)	(86-94%) [D]		
no	9	(4%)	5	(8%)			
don't know or n.a.	7	(3%)	2	(3%)			
***Work loss* when child is sick**							
yes	83	(41%)	30	(48%)			
no	119	(59%)	33	(52%)			
Child with *chickenpox*							
yes	42	(21%)			(23%)[E]	0.90	
no	157	(78%)					
don't know or n.a.	3	(1%)					
Number of *people* in household							
1	1	(0%)	1	(2%)			
2	14	(7%)	3	(5%)			
3	102	(50%)	35	(56%)			
4	65	(32%)	17	(27%)			
5+	19	(9%)	6	(10%)			
Household income before tax							
<£15,000	19	(9%)	2	(3%)	(12%)[F]	0.78	0.27
£15,000-24,999	27	(13%)	10	(16%)	(16%)	0.79	0.97
£25,000-39,999	51	(25%)	22	(35%)	(30%)	0.81	1.17
£40,000-59,999	47	(23%)	12	(19%)	(16%)	1.37	1.16
£60,000+	36	(18%)	8	(13%)	(12%)	1.49	1.10
na	22	(11%)	9	(14%)	(14%)		

A. Birth Statistics, 1999: age of mother: Live births (Office of National Statistics); B. Labour Force Survey, 2000 - women aged 25-44 (Office of National Statistics); C. Labour Force Survey, 2000 - Economic activity status of women: by marital status and children aged less than 5 years (Office of National Statistics); D. http://www.hpa.org.uk/cdr/PDFfiles/2001/cdr2501.pdf - Proportion of fully vaccinated children by 24 months in UK; E. Predicted % of seropositive children using the sero-profile estimated in Brisson *et al*. (54); F. Family Expenditure Survey 1999-2000 - Characteristics of households: by children aged less than 5 years.

Table 5. WTP - Interval regression model with refusals

	WTP for Treatment			WTP for Vaccination		
	Coef	**[95% CI]**	**P>|z|**	**Coef**	**[95% CI]**	**P>|z|**
Constant	169.44	(89.48 to 249.39)	0.000**	187.39	(87.02 to 287.77)	0.000**
Vaccinated			0.009**			0.012**
0	0	Baseline		0	Baseline	
1	-107.36	(-173.68 to -41.04)		-134.24	(-220.12 to –48.36)	
9	-53.61	(-139.89 to 32.66)		-55.45	(-161.18 to 50.28)	
Work loss			0.023**			0.028**
0	0	Baseline		0	Baseline	
1	-31.55	(-58.78 to -4.32)		-38.12	(-72.11 to -4.12)	
Income			0.062*			0.098*
0	0	Baseline		0	Baseline	
1	13.44	(-41.48 to 68.36)		18.15	(-50.13 to 86.43)	
2	35.29	(-14.02 to 84.60)		41.50	(-19.64 to 102.63)	
3	66.81	(16.95 to 116.67)		74.16	(11.92 to 136.40)	
4	58.51	(5.23 to 111.79)		64.64	(-2.01 to 131.30)	
9	44.38	(-14.14 to 102.91)		34.04	(-39.11 to 107.18)	
Start Bid			0.037**			0.014**
0	0	Baseline		0	Baseline	
1	-2.55	(-34.69 to –29.58)		-28.50	(-68.81 to 11.83)	
2	35.10	(2.64 to 67.56)		30.87	(-9.55 to 71.28)	
HUI2	-131.11	(-213.35 to -48.86)	0.002**	-130.44	(-233.61 to –27.27)	0.013**
σ	89.18	(77.52 to 100.83)		109.75	(94.00 to 125.50)	
Log likelihood	-408.63			-395.26		
Null Log-likelihood	-430.06			-414.02		
LRχ^2(12)	42.83		0.000**	37.52		0.000**
Sample size	202			202		

* Significant at p<0.1; ** Significant at p<0.05

Table 6. Analysis of Refusals - Logistic regression model

	WTP for Treatment			WTP for Vaccination		
	Odds Ratio	**[95% CI]**	**P>|z|**	**Odds Ratio**	**[95% CI]**	**P>|z|**
Vaccinated			0.034**			0.003**
0	1	Baseline		1	Baseline	
1	0.16	(0.03 to 0.83)		0.16	(0.04 to 0.72)	
9	0.25	(0.03 to 1.99)		0.11	(0.01 to 0.79)	
Work			0.010**			0.004**
0	1	Baseline		1	Baseline	
1	3.29	(1.41 to 7.68)		2.93	(1.39 to 6.20)	
HUI2	0.001	(0.00 to 0.08)	0.002**	0.07	(0.00 to 1.04)	0.041**
Log likelihood	-74.08			-90.86		
Null Log likelihood	-89.93			-103.26		
Model χ^2(4)	30.99		0.000**	23.87		0.000**
Sample size	200			200		

* Significant at p<0.1; ** Significant at p<0.05

Table 7. WTP - Interval regression model without refusals

	WTP for Treatment			WTP for Vaccination		
	Coef	[95% CI]	P>|z|	Coef	[95% CI]	P>|z|
Constant	88.28	(48.05 to 128.512)	0.000**	97.24	(52.28 to 142.21)	0.000**
Work loss			0.050**			
0	0	Baseline		0	Baseline	0.074*
1	-26.15	(-49.95 to –2.36)		-24.41	(-51.17 to 2.34)	
Income			0.010**			
0	0	Baseline		0	Baseline	0.005**
1	22.89	(-24.51 to 70.29)		34.16	(-18.8 to 87.15)	
2	44.07	(2.36 to 85.77)		42.20	(-3.81 to 88.21)	
3	61.49	(19.77 to 103.21)		79.58	(32.38 to 126.77)	
4	60.09	(14.94 to 105.24)		82.13	(30.40 to 133.86)	
9	84.90	(34.02 to 135.79)		84.19	(27.06 to 141.33)	
σ	73.73	(64.06 to 82.68)		79.43	(68.50 to 90.37)	
Log likelihood	-354.54			-320.63		
Null Log-likelihood	-365.71			-332.27		
LRχ^2(12)	22.34		0.001**	23.28		0.001**
Sample size	173			171		

* Significant at p<0.1; ** Significant at p<0.05

Table 8. Mean WTP and QALY

	England[A]		Sample	
	Mean	[95% CI]	Mean	[95% CI]
WTP analysis				
WTP for Treatment				
With Refusals	90.08	(75.21; 104.95)	98.38	(83.95; 112.81)
Without Refusals	104.63	(89.25; 120.01)	121.61	(109.39; 133.81)
WTP for Vaccination				
With Refusals	96.16	(78.92; 113.41)	105.42	(87.58; 123.26)
Without Refusals	120.21	(103.18; 137.24)	140.45	(126.42; 154.50)
WTP For Vaccine Attributes				
Direct Health Benefit	93.81		110.89	
Altruism	0.00		0.00	
Insurance Type Benefit	15.68		18.84	
Parental Work loss	10.72		10.72	
SG Analysis				
Risk of death	13.74	(8.43 to 19.05)	8.88	(6.80 to 10.95)
QALY analysis				
HUI2-CV[B] all children	0.75	(0.72 to 0.78)	0.76	(0.74 to 0.78)
HUI2-CV[B] history of chickenpox	0.81	(0.75 to 0.87)	0.82	(0.77 to 0.87)
HUI2-SG[C]	0.57	(0.48 to 0.66)	0.56	(0.52 to 0.61)
SG	0.31	(0.05 to 0.58)	0.56	(0.45 to 0.66)

A. Data generated from the study sample re-weighted to represent the population of parents with children of vaccine age in England. Weights used are presented in Table 4.
B. See Appendix for description of chickenpox.
C. See Appendix for descrition of imaginary disease.

Table 9. SG - Interval regression model

	Coef	[95% CI]	P>|z|
Constant	10.05	(4.34 to 15.77)	0.000**
Altruism			
0	0	Baseline	0.009**
1	4.96	(1.23 to 8.70)	
Gender			0.016**
0	0	Baseline	
1	-7.27	(-13.20 to –1.35)	
Degree			0.001**
0	0	Baseline	
1	6.12	(2.49 to 9.75)	
σ	7.10	(5.64 to 8.55)	
Log likelihood	-158.17		
Null Log-likelihood	-166.72		
LR χ^2(3)	17.08		0.001**
Sample size	63		

**Significant at p<0.05

Table 10. HUI2 - Regression model

	Coef	[95% CI]	P>|z|
HUI2 – CV questionnaire			
Constant	0.824	(0.777 to 0.872)	0.000**
Chickenpox			0.008**
0	0	Baseline	
1	-0.077	(-0.130 to –0.023)	
9	-0.188	(-0.371 to –0.004)	
Sample size	202		
HUI2 – SG questionnaire			
Constant	0.608	(0.546 to 0.670)	0.000**
Altruism			0.034*
0	0	Baseline	
1	-0.101	(-0.194 to –0.008)	
Sample size	63		

** Significant at p<0.05

APPENDIX

Box 1.

Description of Chickenpox

- Typically, chickenpox lasts for 7 days
- During this time, your child:
    1. Is covered (face, body and arms) with up to 500 red spots that itch intensely, which is highly frustrating
    2. Has mild fever with cold-like symptoms
    3. Has problems sleeping
    4. Has no problems walking about
    5. Cannot go to school or day care until all the spots have dried or crusted.
    6. Has problems with performing his/her usual activities (e.g. hobbies, sport, playing)
- Working parents take an average 2 days off work per case of chickenpox

Description of <u>Mild</u> Chickenpox

- Typically, mild chickenpox lasts for 5 days
- During this time, your child:
    1. Has only a few red spots
    2. Has no fever or problems walking about
    3. Has some problems with performing his/her usual activities (e.g. hobbies, sport, playing)
    4. Misses 1 day from school or childcare.

Box 2.

Description of the Imaginary Disease

- The disease lasts for 15 years
- During this time, your child:
    1. Is covered (face, body and arms) with up to 500 red spots that itch intensely, which is highly frustrating
    2. Has mild fever with cold-like symptoms
    3. Has problems sleeping
    4. Has no problems walking about
    5. Cannot go to school or day care
    6. Has problems with performing his/her usual activities (e.g. hobbies, sport, playing)